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SAFFLOWER DISEASES

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Safflower is adapted to the wheat and barley areas of the Western United States where dry atmospheric conditions exist during the latter part of the growing season. It is not adapted to the Corn Belt or to the Eastern States. Diseases play a major role in limiting the area of adaptation. NO PRESENT SAFFLOWER VARIETY CAN BE RECOMMENDED FOR AREAS THAT HAVE HIGH ATMOSPHERIC MOISTURE DURING AND AFTER FLOWERING. Unusually excessive rainfall, dews, and humidity will result in damage from diseases.

Safflower is susceptible to certain diseases which limit not only the area of production but also the cultural methods. PLANTING GOOD QUALITY, TREATED, DISEASE-FREE SEED OF A RECOMMENDED VARIETY AT THE RIGHT TIME - PROPER CULTURE AND CONTROL OF SURFACE MOISTURE - AND CROP ROTATION will greatly minimize damage from several safflower diseases. Certain diseases, however, may cause losses and limit production even with the best cultural methods. Control of these must await development of resistant varieties or other feasible control methods.

Some diseases are less serious on nonirrigated or subirrigated safflower than they are on surface-irrigated plants. Nevertheless, certain disease control methods are as valuable to the nonirrigated or subirrigated producer as they are to the surface-irrigator. The rust and Alternaria leaf spot fungi are seed-borne and can cause severe reduction in stand. The use of disease-free, or properly treated seed, gives very good control of these losses. Volatile mercury fungicides are particularly effective as seed treatments. Soil-borne teliospores of the rust fungus left from a previous rusted crop can germinate and attack seedlings and result in a high stand loss. One should avoid planting safflower after safflower if the crop is rusted. Crop rotation is always advisable to discourage a build-up of pathogens. Certain soil-borne fungus pathogens, such as Fusarium and Verticillium, can become so serious in a one-crop system as to make profitable production impossible.

The Botrytis head rot and Alternaria leaf spot fungi appear to be present everywhere and they may attack safflower if atmospheric moisture becomes high. No present commercial varieties are resistant and no feasible control measures are known. Avoid, if possible, using the seed from diseased

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plants for planting. Seed treatment, while giving good control of stand loss from seed-borne fungi, cannot improve the poor quality of seed harvested from diseased plants.

Surface-irrigated safflower is particularly vulnerable to rust and root rot. Although the use of rust-free seed or treated seed and crop rotation give good control of stand loss caused by rust, these practices are not always effective in controlling leaf rust. No present commercial safflower variety is resistant to all rust races and none can be recommended for production where leaf rust is epiphytotic. It is hoped that resistant varieties can be developed.

Root rot is usually most severe on surface-irrigated land. It seldom is a problem on subirrigated or nonirrigated land. RESISTANT VARIETIES GROWN ON BEDS UNDER FURROW IRRIGATION ARE SELDOM DAMAGED SEVERELY BY ROOT ROT.

FUSARIUM WILT AND VERTICILLIUM WILT ARE POTENTIALLY SERIOUS DISEASES OF SAFFLOWER. SEED FROM INFECTED PLANTS SHOULD NOT BE USED FOR PLANTING. CROP ROTATION IS ADVISABLE. NO PRESENT COMMERCIAL VARIETIES ARE RESISTANT.

Growers and other interested parties should consult with their county agent or experiment station for advice on recommended varieties, cultural practices, and seed treatment fungicides.

A description of the more important safflower diseases follows.

RUST

Safflower rust, unlike most rusts, has two distinct pathological phases --a foliage phase and a seedling phase. The foliage phase (fig. 1) results from infection of cotyledons, leaves, and bracts by wind-borne aeciospores and urediospores. The seedling phase (fig. 2) results from infection by sporidia produced by soil-borne or seed-borne teliospores.

Puccinia carthami, the causal agent, may occur wherever safflower is grown. It may frequently become epiphytotic in areas where environmental conditions are conducive for rust development, particularly on irrigated land. The foliage phase of this rust rarely reaches epiphytotic proportions on dryland. Seedling infection can develop in all areas of production where untreated rust-infested seed is used or where plantings are made in fields previously cropped to rusted safflower.

The seedling phase can be particularly damaging. On emerging seedlings, the primary area of infections extends from the transition area to the cotyledonary slit of the hypocotyl epidermis. Pustules resulting from these infections are chestnut-brown, larger than folial pustules, and they frequently coalesce (fig. 2). Initial infection of hypocotyls causes hypertrophy, elongation, and unilateral bending. Longitudinal cracking and splitting of epidermal and cortical tissues of infected hypocotyls is frequent.

Figure 1.--Rust pustules on safflower leaves.

Figure 2.--Rust pustules on hypocotyls and cotyledons of seedlings.

Infected seedlings usually die, often suddenly, without exhibiting above-ground symptoms. The disease can be easily distinguished from root rot by pulling the plant from the ground. Rust-infected plants break at or slightly below the soil surface and on older plants a pronounced girdling and hypertrophy of the stem base has occurred. During wind and rain storms these plants often break at the girdled areas.

The foliage phase is characterized by small powdery chestnut-brown pustules that develop and break through the epidermis of cotyledons, leaves, and floral bracts (fig. 1). The size and development of pustules depends on the susceptibility of the variety. On highly susceptible varieties, the pustules may reach a diameter of 1-2 mm and be surrounded by a secondary and frequently a tertiary ring of uredia. On highly resistant varieties, rust infection may be apparent by only small chlorotic or necrotic flecks without sporulation. The chestnut-brown pustules take on a black appearance as the urediospores are replaced by black teliospores toward the end of the growing season.

Puccinia carthami is composed of several pathogenic races which differ in ability to attack certain safflower varieties and lines. Four North American races have been identified and the presence of additional ones is indicated. No present commercial variety has resistance to all races; however, certain experimental lines are resistant to all known races.

The present lack of rust-resistant varieties for commercial production has focused attention on the use of rust-free seed and crop rotation as exclusionary methods of control. Seed treatment with volatile mercury fungicides, although highly useful for control of stand loss from seed-borne spores, rarely gives perfect control. Complete control is desirable because it would eliminate a primary source of inoculum for foliage infection. Crop rotation has proven effective in reducing loss from soil-borne teliospores. Deep-plowing also may significantly reduce the severity of seedling infection from soil-borne spores.

PHYTOPHTHORA ROOT ROT

Phytophthora root rot is potentially very serious on surface-irrigated safflower. In 1950, several thousand acres of a susceptible variety grown under flood irrigation were killed. The causal fungus, Phytophthora drechsleri, persists in the soil and invades the roots and lower stem under favorable moisture and temperature conditions.

Plants may be attacked at all stages of growth. The first above-ground symptom is wilting of the leaves which have become light green. The plant wilts, dies, and turns brown as a result of breakdown of root tissues. A distinct reddening of tissue occurs in the roots of plants at an early stage of wilting. Infected roots and the lower part of the stem rot and become darkly discolored and blackened in severe cases (fig. 3).

Figure 3.--Phytophthora root rot. Lower stem and roots are rotted and black.

Safflower grown on subirrigated or nonirrigated land is seldom affected severely. Where surface irrigation is required, recommended irrigation practices for specific soil types should be followed. Surface-irrigated safflower should be grown on beds under furrow irrigation instead of flood irrigation. Long irrigation runs and land with poor water penetration or drainage should be avoided. Plants should not be allowed to suffer from lack of water, however, the first irrigation should be delayed as long as possible. Light irrigations applied at frequent intervals are favored over heavy irrigations applied after soil moisture has been depleted.

Some safflower varieties develop resistance after 3 to 6 weeks of growth. Resistant varieties should be used whenever surface irrigation is planned. No commercial varieties are immune.

Pathogenic races of the causal fungus exist. Some present commercial varieties resistant in one area may be susceptible in another area due to differences in races present. It is advisable to check the current and local variety recommendations.

ALTERNARIA LEAF SPOT

Leaf spot, caused by Alternaria carthami, is one of the most serious diseases of safflower in the Great Plains. It may affect both irrigated and nonirrigated plants. It is particularly severe during July and August if frequent heavy dews or showers occur. Fortunately, the weather during most summers is not conducive to severe leaf spot development.

The disease is characterized by large, brown, somewhat irregular spots on leaves and flower bracts. The fungus also discolors seed, and causes seed rot and damping-off of seedlings.

Present commercial varieties, although slightly tolerant, are not resistant. Seed treatment with a volatile mercury fungicide gives very good control of the stand losses which result from seed rot and damping-off.

VERTICILLIUM WILT

Verticillium wilt of safflower is caused by a soil-borne and seed-borne fungus, Verticillium albo-atrum. This wilt, observed in all major safflower growing areas, has never reached epiphytotic proportions. Cool, wet weather favors the wilt. Plants may be attacked at any stage of development. Disease symptoms differ somewhat depending on the stage at which the plant is attacked.

The fungus enters the plant through the roots and inhabits the vascular tissue of the roots, stems, and leaves. Infected plants may show a dark discoloration in the vascular strands, especially at the nodes and in the petioles and leaf traces. Cotyledons of infected safflower plants become yellowish, flaccid, and soon dry out. Young plants often show considerable stunting. The leaves appear darker green than those of normal plants and frequently are crinkled between the veins.

In older plants, symptoms occur in lower leaves first and spread to the middle and upper leaves. Infected leaves frequently exhibit unilateral growth and discoloration (fig. 4). An outstanding symptom is chlorotic areas on the leaf margins and between the principal veins, giving them a mottled appearance. As plants age, the chlorotic areas gradually become larger and paler. Severely infected plants die prematurely and rarely produce viable seed.

All present commercial varieties are susceptible. Seed from diseased fields should not be used for planting. Rotation with a crop not susceptible to Verticillium wilt is strongly advised.

Figure 4.--Leaf symptoms of Verticillium wilt (B) compared with healthy leaves (A). Note unilateral growth and discoloration of diseased leaves.

BOTRYTIS HEAD ROT

Botrytis rot or blight of safflower seed-heads commonly occurs where high atmospheric moisture conditions prevail. Fog, rain, and heavy dews enhance infection of flowering heads by the causal fungus Botrytis cinerea. Spores of the fungus are wind-borne and are generally prevalent in the air. Infection occurs after blossoms appear and may take place after flower parts have shriveled.

A change in color of the infected seed-head from dark to light green is an early symptom (fig. 5) and is followed by complete browning. The stage of bloom at time of infection determines whether seed may be lacking, lighter-than-normal, or fully developed. The fungus progresses through the seed-head and into the stem, rendering infected heads readily detachable from the plant.

No commercial varieties are resistant to this disease. Varietal resistance is needed in areas where environmental conditions are conducive for disease development. Safflower culture is not recommended in such areas with present commercial varieties.

Figure 5.--Botrytis head rot: A, Diseased plants with lighter color of head; B, Healthy plants.

MOSAIC

Mosaic caused by cucumber mosaic virus, is common on a number of wild and cultivated plants. This virus is spread from infected plants by winged, green-peach aphids, Myzus persicae. Infection apparently occurs early in the growing season.

Cucumber mosaic on safflower is characterized by a light- and dark-green mosaic pattern on leaves and involucral bracts. The mosaic pattern is less distinct on lower, shaded leaves, changing to interspersed light- and dark-green flecks. Some leaves may become blistered and distorted. Virus-infected plants may be stunted but develop to maturity.

No commercial varieties appear to be resistant. Varietal resistance, however, is desirable since aphid-control may not be a feasible practice.

FUSARIUM WILT

The causal fungus, Fusarium oxysporum Schl. f. carthami, penetrates the roots and invades the vascular tissue. It persists in soil and in plant debris.

A characteristic symptom is yellowing of leaves on one side of the plant. Unilateral yellowing is also typical on leaves and some seed-heads (fig. 6). Yellowing begins on the lower leaves and as the disease progresses wilting

Figure 6.--Fusarium wilt symptoms: A, Healthy plant; B, Diseased plant with symptoms only on some lower leaves; and C, Diseased plant showing severe wilt.

occurs, and the entire plant may be killed. Young plants usually are killed. Older plants may die but generally only branches on the affected side of the plants are killed. A brown discoloration of the vascular tissue occurs in the roots and stem.

Present commercial varieties are susceptible; however, some may be more tolerant than others. Since the fungus may be seed-borne, seed harvested from diseased fields should not be used for planting. Safflower should not be planted in fields where the disease occurred the previous year.

SCLEROTINIA ROT

A stem and head rot of safflower is caused by the fungus Sclerotinia sclerotiorum. This fungus persists in soil and on plant debris mainly in the form of sclerotia. Infection of plants occurs on the stem at or near the ground level, when cool and moist conditions prevail.

This disease can be mistaken for Phytophthora root rot because of similarity in above-ground symptoms. Leaves turn yellow, wilt, shrivel, and turn brown as the whole plant is killed. Tops of dead plants may be curved downward. Internal stem tissue turns brown and the cortical tissue shreds easily as the fungus rots the stem. A distinguishing characteristic of this disease is the presence of black sclerotia in the hollowed stem usually near the soil line. These can be readily found in old dead plants. No rotting or discoloration of the root occurs.

Sclerotinia also causes a head rot which is similar to Botrytis head rot. Seed development may be impaired and lighter than normal seed may be produced.

Varietal resistance to this disease has not been evaluated. Since the fungus is seed-borne, seed harvested from diseased fields should not be used for planting. Safflower may be damaged when it follows crops in rotation which are susceptible to Sclerotinia, such as lettuce and beans.